III. Claim Amendments

Applicants have amended Claim 20 to indicate that the lasing element of the laser system can be Er^{3+}:glass. Support for this amendment can be found on page 5, lines 22-24 of the specification.

IV. Rejection of Claims 18 and 19 Under 35 U.S.C. § 112, First Paragraph

The Examiner rejects Claims 18 and 19 under 35 U.S.C. § 112, first paragraph because the Examiner states that Applicants do not recite a material to support the wavelengths in the phrases "band within about 4 nm" and "band within about 2 nm."

Claims 18 and 19 directed to a laser system in which the saturable absorber Q-switch has an absorption band within about 4 nm (Claim 18) or about 2 nm (Claim 19) of the lasing transition of the lasing element. Applicants have indicated that the efficiency of a lasing system is increased when the absorption band of a saturable absorber Q-switch is close to the lasing transition of the lasing element (page 4, lines 7-15 and on page 13, lines 14-18 of the specification). The lasing transition of the Er:Yb:glass laser is about 1540 nm. Applicants have prepared saturable absorber Q-switch that has an absorption band at 1544 nm which is within 4 nm of the lasing transition of the Er:Yb:glass lasing element (page 13, lines 14-15 of the specification). Applicants have indicated that the absorption band of the saturable absorber Q-switch can be modified by changing the amount of aluminum to magnesium in the Q-switch and that as the amount of aluminum relative to the amount of magnesium decreases the $^4T_1$ absorption band shifts to shorter wavelengths. For example, when the Q-switch composition is $MgAl_2O_4$, the $^4T_1$ absorption band is 1536 nm, when the Q-switch composition is $MgAl_4O_7$, the $^4T_1$ absorption band is 1537 nm, and when the Q-switch composition is $MgAl_6O_{10}$, the $^4T_1$ absorption band is 1544 nm (page 18, Table I, absorption wavelength for $^4T_1$ absorption band). In addition, Applicants have shown that at low temperatures (8 °K) the 4T1 absorption band of the $MgAl_2O_4$ Q-switch is shifted to 1539 nm which is within 1 nm of the lasing transition of the Er:Yb:glass lasing element. Thus, a person of ordinary skill in the art would be able to prepare a saturable absorber Q-switch that has an absorption band within 2 nm or 4 nm of the lasing transition of the lasing element, such as a Er:Yb:glass lasing element, of a laser system by changing the amount of aluminum to magnesium in the Q-switch and/or varying the temperature

of the Q-switch, as disclosed by Applicants. Therefore, Applicants respectfully request that the rejection be reconsidered and withdrawn.

V. Rejection of Claims 1-15 and 33-47 Under 35 U.S.C. § 102(b) Over Konstantin V. Yumashev, *Applied Optics* (1999), *38*(30):6343 (Hereinafter "Yumashev")

A. Summary of the Examiner's Rejection

In regard to composition Claims 1-3, 7 and 47, the Examiner states that Yumashev discloses a saturable absorber Q-switch that has a monocrystalline lattice and a chemical formula of $Mg_{1-x}Co_xAl_yO_z$ in which x, y, and z are in the range of Applicants' invention. In regard to composition Claims 4-7, the Examiner states that the saturable absorber Q-switch disclosed by Yumashev has a chemical formula of $Mg_{1-x}Co_xAl_yO_z$ in which z is about 4 to 10 and y is about 4 to 6. In regard to composition Claims 8-15, the Examiners states that the saturable absorber Q-switch disclosed by Yumashev has an absorbance band between about 1.34 μm and 1.54 μm.

The Examiner does not state any grounds for rejecting method Claims 33-46 but states that he considers the methods of forming to be product-by-process steps.

B. Summary of Applicants' Invention

Applicants claim a saturable absorber Q-switch (Claims 1-15) that has a monocrystalline lattice composed of a compound represented by the formula $Mg_{1-x}Co_xAl_yO_z$, wherein x is greater than 0 and less than about 1, y is greater than 2 and less than about 8, and z is between about 4 and about 13. The monocrystalline lattice has octahedral and tetrahedral positions, and most of the tetrahedral positions are occupied by Mg or Co.

Applicants also claim a saturable absorber Q-switch that has a monocrystalline lattice of cobalt-doped spinel in which the molar ratio of aluminum to the combined molar amount of cobalt and magnesium is greater than 2 (Claim 47). Essentially all of the cobalt and magnesium occupy tetrahedral positions.

Applicants claim a method of forming a saturable absorber Q-switch (Claims 33-46). In Applicants' method, a melt is formed that includes magnesium, cobalt, aluminum and oxygen. The molar ratio of magnesium:cobalt:aluminum in the melt is (1-x):x:y, wherein x is greater than 0 and less than about 1, and y is greater than 2 and less than about 8. A spinel seed crystal is

immersed in the melt and rotated at a rate in the range of between about 2 and about 12 revolutions per minute, while withdrawing the seed crystal from the melt at a rate in a range of between about 0.04"/hr and about 0.1"/hr.

C. Summary of Yumashev

Yumashev discloses a saturable absorber Q-switch that is composed of a compound having the chemical formula $MgAl_2O_4$ (Yumashev, abstract and page 6343, Col. 1, lines 13-17) and is doped with Co^{+2} at a concentration of 0.1-0.5 wt. % (Yumashev, page 6343, Col. 2, lines 6-7).

D. Composition Claims 1-15 and 47

Applicants' claimed saturable absorber Q-switch is composed of a material that is represented by the formula $Mg_{1-x}Co_xAl_yO_z$. Claim 1 requires that y is greater than 2.

The saturable absorber Q-switches disclosed by Yumashev have a chemical formula of $MgAl_2O_4$. Therefore, the Q-switches disclosed by Yumashev have a composition in which y is equal to 2 and do not satisfy the limitation in Applicants' Claim 1 that y is greater than 2.

In order to anticipate a claim, a reference must teach every element of the claim (see M.P.E.P. § 2131). Since Yumashev does not disclose a saturable absorber Q-switch that satisfies the limitation of Applicants' Claim 1 that y is greater than 2, Claim 1, and the claims depending therefrom, are not anticipated by Yumashev. Therefore, Applicants respectfully request that the rejection of Claims 1-15 over Yumashev be reconsidered and withdrawn.

Applicant's Claim 47 is directed to a saturable absorber Q-switch that has a cobalt-doped spinel in which the molar ratio of aluminum to cobalt and magnesium is greater than 2 (i.e., $Al/(Co + Mg) > 2$).

Yumashev discloses a Q-switch that is a spinel have a composition of $MgAl_2O_4$ and is doped with cobalt. The cobalt substitutes for the magnesium in the lattice structure (Yumashev, page 6343, Col. 2, lines 3-5).

It is evident from examining the spinel formula of Yumashev's Q-switches that the molar ratio of aluminum to cobalt and magnesium is equal to 2 (i.e., $Al/(Co + Mg) = 2$). Since Yumashev does not disclose a saturable absorber Q-switch that satisfies the limitation of

Applicants' Claim 47 that the molar ratio of aluminum to cobalt and magnesium is greater than 2, Claim 47 is not anticipated by Yumashev. Therefore, Applicants respectfully request that the rejection of Claim 47 over Yumashev be reconsidered and withdrawn.

E. Method Claims 33-46

A product-by-process claim is a product claim that defines the claimed product in terms of the process by which it is made (see M.P.E.P. § 2173.05(p)(I)). Applicants' Claims 33-46 do not claim a product. Therefore, they are not product-by-process claims and cannot be anticipated by a reference that discloses a product without disclosing the claimed method.

Applicants' Claims 33-46 are directed to a method of forming a saturable absorber Q-switch that involves forming a melt that includes magnesium, cobalt, aluminum and oxygen. A spinel seed crystal is immersed in the melt and rotated.

Yumashev does not disclose any of the steps of Applicants' claimed method. Therefore, Applicants' method Claims 33-46 are not anticipated by Yumashev, and Applicants respectfully request that the rejection be reconsidered and withdrawn.

VI. Rejection of Claims 16-32 Under 35 U.S.C. § 103(a) Over Stultz et al., U.S. Patent No. 5,654,973 (Hereinafter "Stultz") in View of Yumashev

A. Summary of the Examiner's Rejection

The Examiner states that Stultz discloses a laser system that has a laser resonator cavity defined by a flat mirror (28) and an outcoupler mirror (30) which are oriented to form an optical resonant axis; a lasing element (34) within the laser resonator cavity; an optical pumping means (36) proximate to the lasing element; and a saturable absorber Q-switch (38) lying along the resonant axis.

The Examiner states that Stultz does not disclose a Q-switch that has a monocrystalline lattice composed of a material represented by the formula $Mg_{1-x}Co_xAl_yO_z$. However, the Examiner states that Yumashev discloses a monocrystalline lattice having a formula $Mg_{1-x}Co_xAl_yO_z$, where x, y, and z are in the range of the claimed invention. Therefore, the Examiner states that it would have been obvious at the time of the invention was made to a person having ordinary skill in the art to modify Stultz to employ the material of Yumashev

because the Examiner believes that those skilled in the art would recognize that such modification and variations can be made without departing from the spirit of the invention.

B. Summary of Stultz

Stultz teaches a lasing system that employs a passive Q-switch (Stultz, Col. 2, lines 26-27). The Q-switch utilizes Co^{2+} saturable absorber ions in a host material such as a garnet-type crystal (Stultz, Col. 2, lines 47-48). Stultz does not teach or suggest that the disclosed Q-switch could be made from a material having the formula $Mg_{1-x}Co_xAl_yO_z$, wherein y is greater than 2.

C. The combination of the references do not disclose all of the claim limitations of Applicants' claimed lasing system.

Applicants' claimed lasing system has a saturable absorber Q-switch that is composed of a material that is represented by the formula $Mg_{1-x}Co_xAl_yO_z$. Claim 16, and the claims depending therefrom, require that y is greater than 2. Cobalt doped saturable absorber Q-switches that have a ratio of aluminum to magnesium that is greater than that of spinel ($MgAl_2O_4$) enables adjustment of the $^4T_1$ spectrum of cobalt dopant to more closely match a peak of 1544 nm, which is the lasing wavelength of an erbium:ytterbium:glass laser. In addition, increasing the ratio of aluminum to magnesium of spinel enables the Q-switch to emit a band at about 1340 nm, which is about the lasing wavelength of a Nd^{3+}:$YAlO_3$ laser. More closely matching of the emission band of the saturable absorber Q-switch to the lasing wavelength can significantly increase the efficiency of a lasing system (see specification page 4, lines 3-16).

As discussed above, the saturable absorber Q-switches disclosed by Yumashev have a chemical formula of $MgAl_2O_4$. Therefore, the Q-switches disclosed by Yumashev have a composition in which y is equal to 2 and do not satisfy the limitation in Applicants' Claim 16 that y is greater than 2. Stultz does not remedy this deficiency because the saturable absorber Q-switches disclosed by Stultz are not composed of a monocrystalline lattice having formula $Mg_{1-x}Co_xAl_yO_z$, wherein y is greater than 2.

M.P.E.P. § 2143 states that, to establish a case of *prima facie* obviousness, ". . . the prior art reference (or references when combined) must teach or suggest all the claim limitations." In the instant case, neither Stultz or Yumashev teach or suggest a saturable absorber Q-switch that

is composed of a monocrystalline lattice having the formula $Mg_{1-x}Co_xAl_yO_z$, wherein y is greater than 2. Therefore, the references, either alone or in combination, do not teach all of the limitations of Applicants' claimed lasing system, and Applicants respectfully request that the rejection be reconsidered and withdrawn.

SUMMARY AND CONCLUSIONS

Applicants' claimed saturable absorber Q-switch is formed of a monocrystalline lattice having the formula $Mg_{1-x}Co_xAl_yO_z$, wherein y is greater than 2. The emission band of cobalt doped Q-switches in which the ratio of aluminum to magnesium is greater than the ratio found in spinel ($MgAl_2O_4$) can more closely match the lasing wavelength of some lasers and, thus, can significantly increase the efficiency of a lasing system. Neither Yumashev or Stultz teach or suggest a Q-switch made of a monocrystalline lattice having the formula $Mg_{1-x}Co_xAl_yO_z$, wherein y is greater than 2. Therefore, Applicants claimed Q-switch and lasing system employing the same are novel and non-obvious over Yumashev or Stultz, either alone or in combination.

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned at (978) 341-0036.

Respectfully submitted,

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Dated: 1/28/03

MARKED UP VERSION OF AMENDMENTS

Specification Amendments Under 37 C.F.R. § 1.121(b)(1)(iii)

Replace the paragraph at page 7, lines 4 through 7 with the below paragraph marked up by way of bracketing and underlining to show the changes relative to the previous version of the paragraph.

> Typically, the amount of cobalt ion in the saturable absorber Q-switch of the invention is greater than about 0.02 atomic percent. Preferably, the amount of cobalt ion present is in an amount in a range of between about 0.02 and about 0.043 [(]atomic[?) weight] percent of the monocrystalline lattice.

Claim Amendments Under 37 C.F.R. § 1.121(c)(1)(ii)

20. (Amended) The laser system of Claim 17, wherein the lasing element is an Er:Yb:glass <u>or</u> [(]Er^{3+}:glass[?)] lasing element.